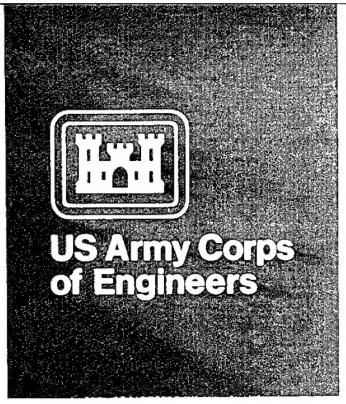

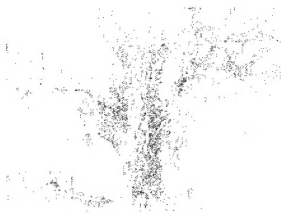

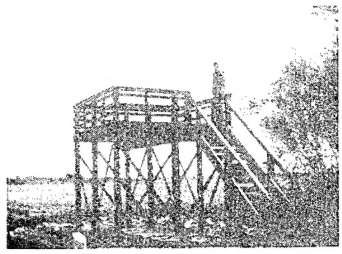

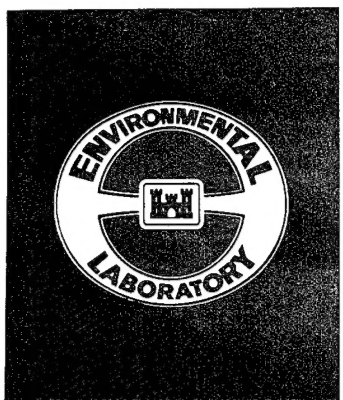

ENVIRONMENTAL IMPACT
RESEARCH PROGRAM

TECHNICAL REPORT EL-95-22

LINE INTERCEPT

Section 6.2.5, U.S. ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

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July 1995
Final Report

Prepared for DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under EIRP Work Unit 32420

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PREFACE

This work was sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Environmental Impact Research Program (EIRP), Work Unit 32420, entitled Development of U.S. Army Corps of Engineers Wildlife Resources Management Manual. Mr. Dave Mathis was the EIRP Coordinator at the Directorate of Research and Development, HQUSACE. The Program Monitors for the study were Dr. John Bushman, Mr. F. B. Juhle, and Mr. Forrester Einarsen, HQUSACE.

This report was prepared by Dr. Wilma A. Mitchell, Stewardship Branch (SB), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), and Dr. H. Glenn Hughes, School of Forest Resources, Pennsylvania State University (DuBois campus), DuBois, PA. Dr. Hughes was assigned to EL under an Intergovernmental Personnel Act agreement during the development of this report. Mr. Chester O. Martin, SB, was principal investigator for the work unit. WES review was provided by Messrs. Martin, Michael R. Waring, and Darrell Evans, SB.

The report was prepared under the general supervision of Mr. Hollis Allen, Acting Chief, SB, EL; Dr. Robert M. Engler, Chief, Natural Resources Division, EL; and Dr. John W. Keeley, Director, EL. Dr. Russell F. Theriot, WES, was the EIRP Program Manager.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Bruce K. Howard, EN, was Commander.

This report should be cited as follows:

Mitchell, Wilma A., and Hughes, H. Glenn. 1995. "Line Intercept: Section 6.2.5, U.S. Army Corps of Engineers Wildlife Resources Management Manual," Technical Report EL-95-22, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

NOTE TO READER

This report is designated as Section 6.2.5 in Chapter 6 -- CENSUS AND SAMPLING TECHNIQUES, Part 6.2 -- VEGETATION SAMPLING TECHNIQUES, of the U.S. ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 6.

LINE INTERCEPT

Section 6.2.5, U.S. ARMY CORPS OF ENGINEERS

WILDLIFE RESOURCES MANAGEMENT MANUAL

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The line intercept method was developed for sampling range vegetation in the southwestern United States (Canfield 1941). The procedure consists of recording the amount of canopy cover intercepting a meter tape laid along the surface of the ground (Fig. 1). Canopy cover is recorded in decimeters by contributing plant species, and data analysis provides estimates of total or species ground cover for a site.

Line intercept is effectively used for the estimation of ground cover on shrublands and compares favorably with other methods used to sample plant communities in arid habitats (Bauer 1943, Johnston 1957, Kinsinger et al. 1960, Schultz et al. 1961, Brun and Box 1963, Whitman and Siggeirsson 1954, Hanley 1978). Line intercept is widely recommended as a technique for measuring cover and species composition of shrub ecotypes (Cook and Bonham 1977, Hays et al. 1981, Chambers and Brown 1983, Cook and Stubbendieck 1986). Numerical abundance and frequency can also be measured with this technique (Oosting 1956).

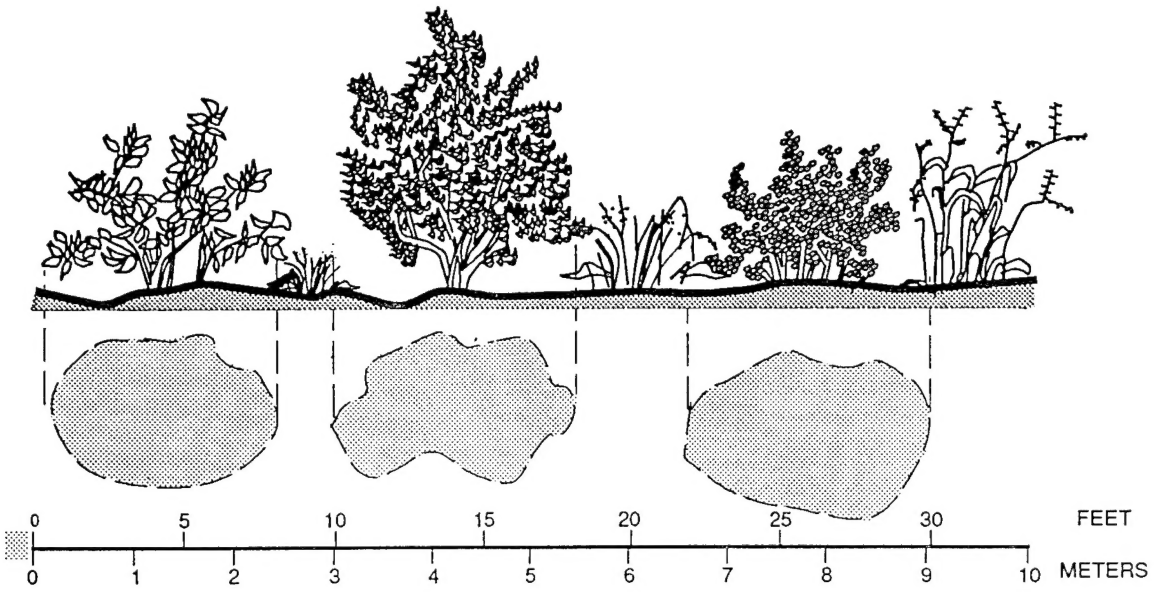

Figure 1. Use of the line intercept method as described by Canfield (1941)

Line intercept may be applied to herbaceous and tree canopy cover but is not as efficient or reliable as other methods such as point sampling. The technique described in this report pertains only to shrub communities.

ASSUMPTIONS

Tests indicate that length of plot contributes greatly to the amount and reliability of information obtained from a sample (Canfield 1941); in general, oblong and oval plots have proved to be more effective than square or round plots. Line intercept involves measurement of the intercepted lengths of an "elongated plot without width." It is based on the principle of reducing the belt-transect, which has two dimensions (length and width), to a line with only one dimension, length (Mueller-Dombois and Ellenberg 1974). Therefore, this technique maximizes the effect of length by using a line as the sampling unit. It is assumed that a line, because of its greater length, increases the likelihood of encountering more plants and kinds of vegetation than does a plot. Since the distribution of vegetation seldom follows straight lines, the chance of measuring a disproportionate share of the unusual, such as the occasional group or family of plants, is reduced by using a long, narrow sampling unit (Canfield 1941).

TECHNIQUE SELECTION

Major reasons for selecting line intercept are its suitability for shrublands, reliability, ease of application, and efficiency. These attributes are discussed below in more detail.

Cover Estimation

Line intercept is most appropriate for sampling shrubs with well-defined, dense crowns (Chambers and Brown 1983), especially in desert communities where the plants are widely spaced (Cook and Bonham 1977) (Fig. 2). The technique is not suitable for measuring cover in communities or stands in which vegetative types are intermingled and plant boundaries are indistinct (Larson 1959). Permanent transects can be established and periodically sampled to measure changes in vegetation over time, such as those resulting from fire, browse utilization, or regeneration (Larson 1959).

Reliability

Line intercept is a reliable technique, showing only a small sampling error when evaluated on an artificial population (Schultz et al. 1961) and yielding

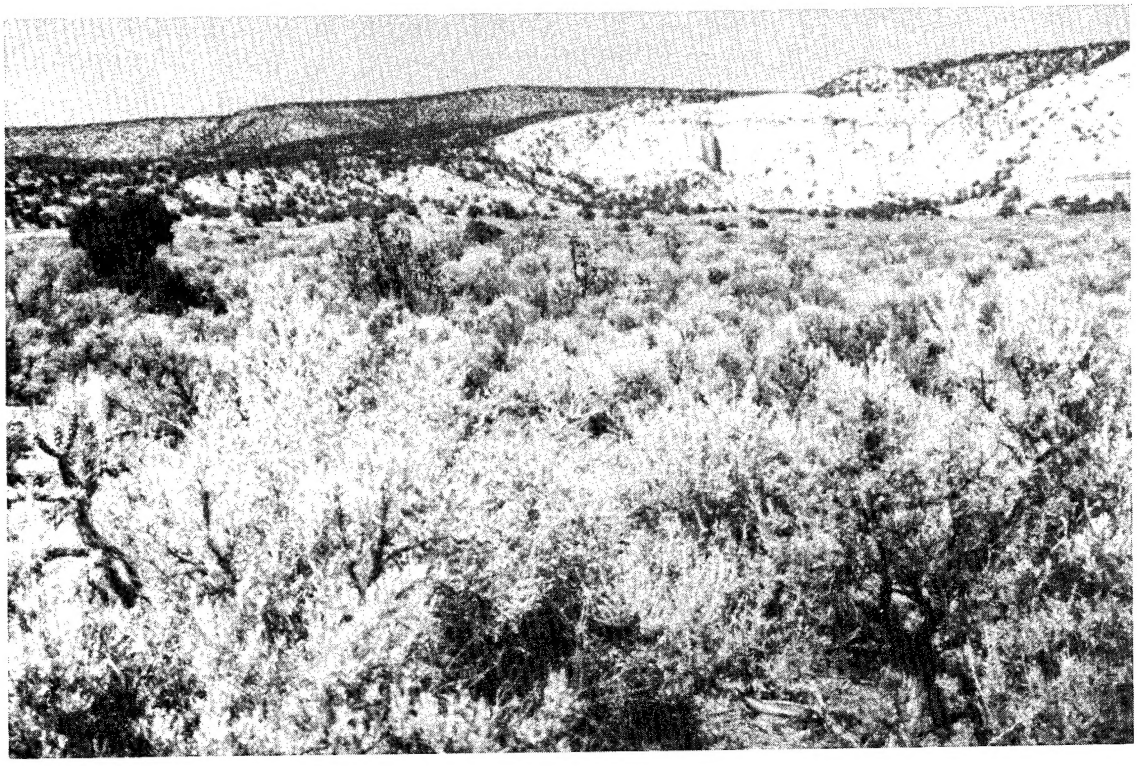

Figure 2. Line intercept is useful for sampling shrubs with well-defined crowns, such as those found on shrublands in New Mexico

comparable results with other sampling methods (Bauer 1943, Kinsinger et al. 1960, Winkworth et al. 1962, Brun and Box 1963, Hanley 1978). It provides a direct measurement rather than a visual estimate, thus reducing bias and rendering the technique particularly useful when high levels of precision and confidence are required.

Application

The procedure is easy to learn and apply. In 1 field-day, personnel can be trained to perform it accurately and efficiently. Equipment is minimal and lightweight; the only requirements are a reel tape, several stake flags, and data recording materials.

Efficiency

As described by Canfield (1941), line intercept requires more time than point sampling and visual estimation (Johnston 1957, Heady et al. 1959, Winkworth et al. 1962, Brun and Box 1963). Heady et al. (1959) found that it required 52% more time than point sampling to obtain comparable results. However, the modifications described in this report allow greater efficiency of the technique than does the original design.

STUDY DESIGN

Site Selection

The sites to be sampled should be selected and located on a map of the study area prior to data collection. Sites should be randomly selected if the study area is large and the shrub communities are fairly homogeneous. However, if the study area consists of communities that have widely diverse structural components (i.e., species composition, density, plant height), it may be preferable to select representative sites in proportion to the amount of area occupied by each. Aerial photographs can be used to detect differences in plant densities and distributions.

Transect Establishment

Description. Transects (commonly referred to as lines) may be randomly or systematically located at a site but must be spaced far enough apart to prevent sampling overlap. Line length varies among studies but is generally from 10 to 100 m (35 to 350 ft) (Chambers and Brown 1983). A 15-m (50-ft) line is sufficient for sampling areas with an estimated 5% to 15% ground cover, whereas a line of 30 m (100 ft) should be used on very sparsely vegetated areas (0.5% to 3% ground cover) (Canfield 1941). Many short transect lines are preferable to

a few long lines. Chambers and Brown (1983) stated that a minimum of 5 to 10 lines is required for an adequate sample. It is suggested in this report that at least twenty 15-m (50-ft) lines be sampled on a site of 40 ha (100 acres).

Sample size. A preliminary statistical test may be applied to 16 or 20 lines of data to determine whether the study area is being sampled at the proper intensity. A formula used to calculate sample size (Snedecor 1950) is

$$N = \frac{s^2 t^2}{d^2}$$

where

N = number of sample points required

s = standard deviation

t = t-value with n-1 degrees of freedom

d = allowable error (i.e., arithmetic mean of the sample total times the designated percent accuracy)

The heterogeneity of vegetation affects sample size more than the size of the area sampled. The test should be performed on sites with different shrub densities, and the sample size should be adjusted accordingly. For example, the number of lines per site may need to be increased to correct for inadequate sampling in sparse vegetation (<5% ground cover), whereas the number may need to be decreased to avoid oversampling where shrubs are denser (>15% ground cover).

Sampling Procedure

After a transect is established, the amount of cover is measured and recorded by species for each shrub bisected by the tape line. The portion of a shrub underneath the canopy of a larger one is not measured, as cover overlap will result in an overestimation of total cover. When a shrub has bushy branches that reach across the tape with large gaps in between, the gaps should not be included in the measurement; however, small gaps within plants are best ignored and counted as part of the canopy cover (Chambers and Brown 1983).

Data are summarized by transect line for statistical analysis. The total linear measurements for all intercepts along a transect represent the percentage ground cover for the entire line. Percent cover may be calculated for individual species, a sample site, or a total area of similar communities.

EQUIPMENT

The items of equipment needed for this procedure are 2 stake flags and a linear reel tape long enough to exceed the transect length. The tape is used to read the linear depth of shrub canopy, and the flags are used to mark the transect ends. A 30-m (98-ft) fiberglass tape and a bundle of 100 stake wire flags can be purchased from forestry suppliers for less than $50.00 (1994 prices).

PREPARATION

Users should be proficient in applying the line intercept technique before data collection begins. Field personnel should learn shrub identification and practice defining canopy boundaries, the points at which readings are taken. Crew members are required to use a compass to pace straight transect lines, and each member should determine the number of paces required to establish a transect. It is recommended that field personnel conduct trial runs in typical shrub habitat prior to the actual study.

DATA COLLECTION

Data collection is easier and produces more accurate results when conducted with a field crew of 3 members, but it can be done with only 2 members. Both procedures are presented below.

Procedure 1: 3-Member Crew

1. A stake flag is placed to mark the starting point of the transect. One person holds the end of the tape over the point and records data.
2. A second person takes the tape reel and establishes the transect by walking a compass line to the end of the transect and marking it with a stake flag. The tape is held over this point as in step 1. (The direction traveled to define the transect may be either fixed or random, but lines must not overlap.)
3. The crew members at the transect ends stretch the tape tautly with absolutely no sagging, while a third person (observer) reads the amount of shrub canopy that intercepts the tape. The observer calls out the species of shrub, the decimeter on the tape that marks the beginning of cover, and the decimeter that marks the end of cover (Fig. 3). Caution: Canopy is not measured if it is encompassed by a larger

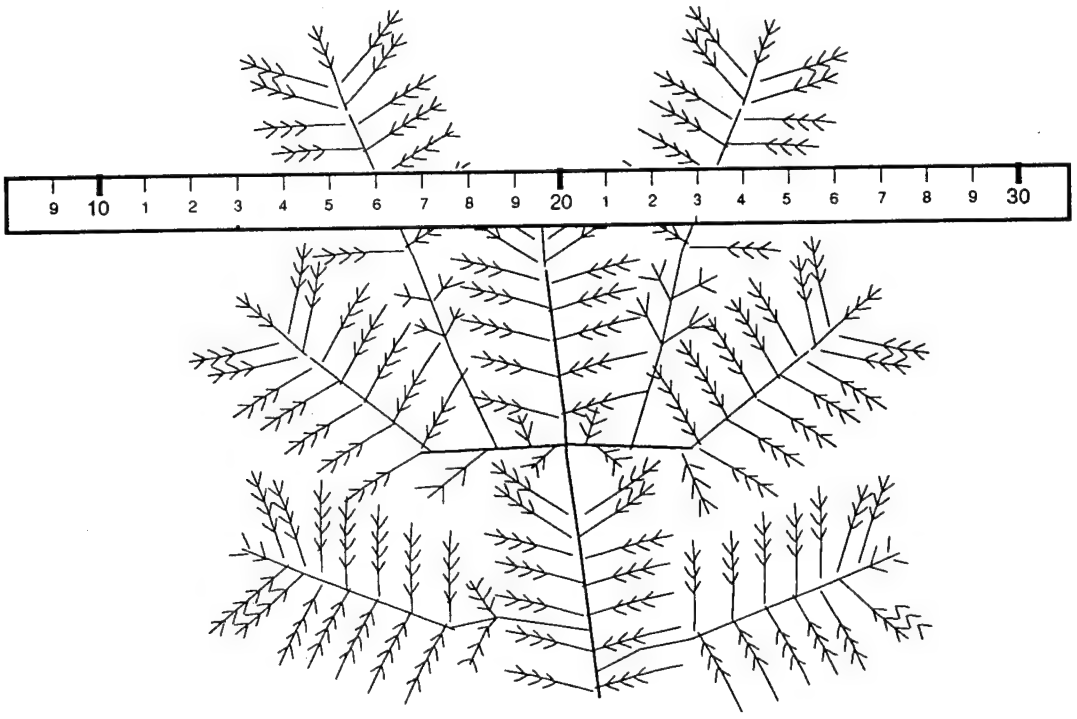

Figure 3. Shrub canopy intercepts the tape line beginning at 12 dm and ending at 28 dm

shrub canopy. Figure 4 shows a view from above a transect line with intercepts indicated.

4. The field crew moves to the next sampling station and repeats the above procedure.

Procedure 2: 2-Member Crew

1. A stake flag is placed to mark the starting point of the transect. One person holds the end of the tape over the point and records data.

2. The second person (observer) paces the length of the transect and marks the end with a stake flag.

3. The observer takes the tape from the first point and walks the length of the transect while reading the width of each shrub canopy over which the tape passes. The observer calls out the actual number of decimeters intercepted by a shrub canopy rather than the beginning and ending units. This is convenient because the first unit reading is always 0 dm.

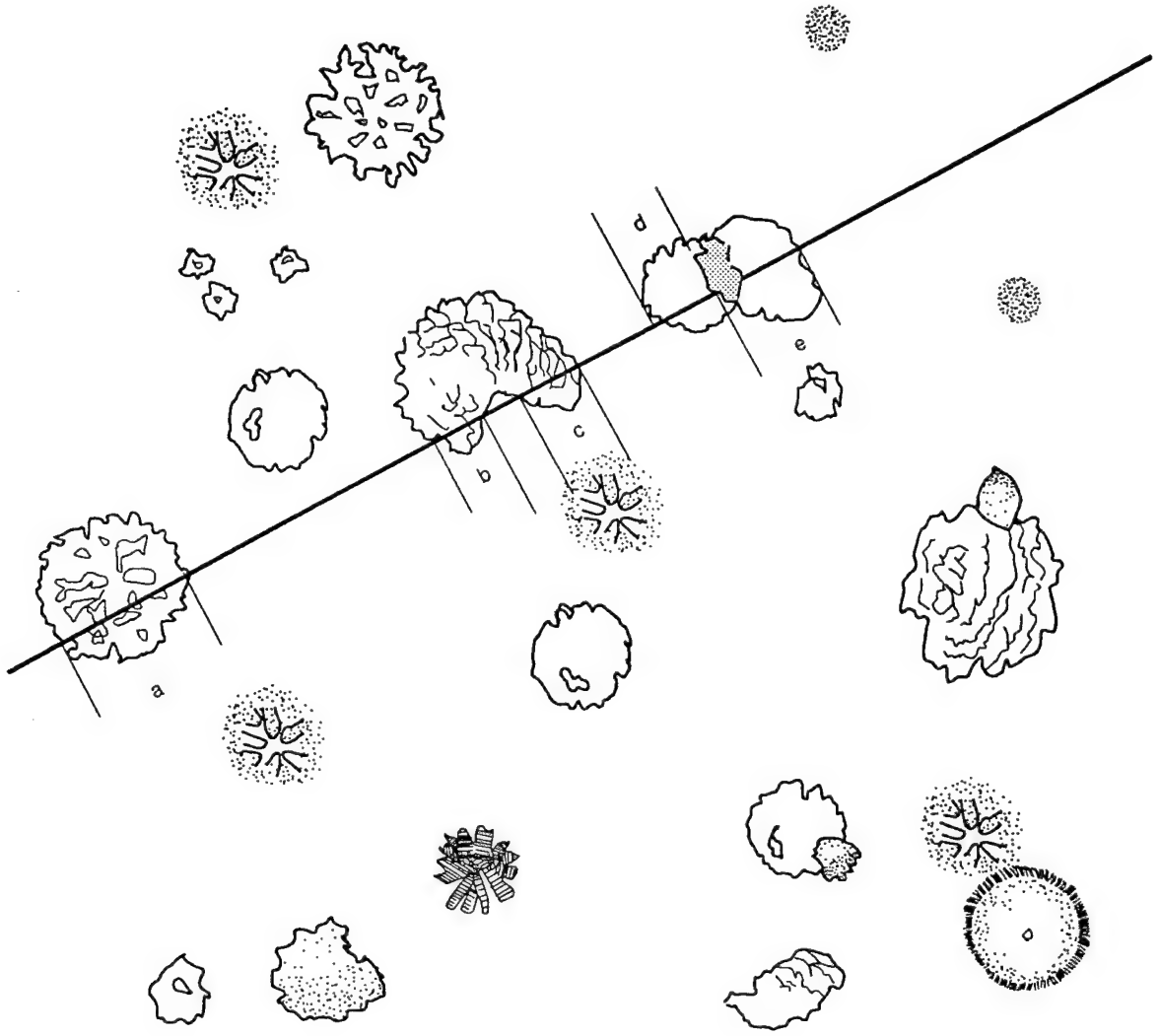

Figure 4. View from above a transect with intercepts (a, b, c, d, e) indicated

Caution: Some canopies encompass so much linear depth that the observer may have difficulty obtaining an accurate reading while also holding the tape.

4. The field crew moves to the next sampling station and repeats the above procedure.

Outlines of the procedures without illustrations are provided in Appendix A. The single instruction sheet is convenient to carry into the field as a reminder after the technique has been essentially learned.

DATA RECORDING

Blank data forms are provided in Appendix B. The one entitled "LINE INTERCEPT: FIELD DATA SHEET" is used to record the amounts of canopy cover measured in the field. Four items of data are recorded for each shrub: transect line number (recorded only at the first plant encountered), species name, the unit of measure where canopy cover is encountered, and the unit that marks the end of cover. (The amount of cover in column E-B may be calculated later.) An abbreviated name or code number is entered for species, and canopy cover is recorded to the nearest decimeter. When two people collect data, only the amount of cover (column E-B) is entered; columns B and E are left blank.

A sample data sheet containing actual field data is used to illustrate data recording (Fig. 5). On the first transect (Line 1), canopy cover was measured for 2 shrubs, and species names were recorded using the first 2 letters of the generic and specific names; cover was recorded to the nearest decimeter. The first shrub measured on Line 1 was four-winged saltbush (*Atriplex canescens*), recorded as "Atca." The beginning (B) of its boundary was at 5 dm and the end (E) was at 7 dm. The length of the tape line intercepted by the shrub canopy was 2 dm (E - B).

There is no standard method for recording species name. In the examples given below, species name was recorded by using the first 2 letters of the scientific name. Other methods include recording the initial letters of the common name or assigning a code number to each species. The latter method is preferable for entering data into a field computer.

DATA ANALYSIS

The data sheet entitled "LINE INTERCEPT: DATA ANALYSIS" (Appendix B) is used for data calculations. The transect numbers are entered in the first column, "Line Number," and the names of the shrub species measured at a site are entered in the blocks under "Amount Cover By Species."

Calculations

Data analysis consists of determining the amount and average percentage of shrub canopy cover within a stand. Decimeters are converted to meters for the calculations, since the variables must be in the same units. Total canopy cover for each species, for each line, and for the stand can then be found by following the steps below, which are illustrated in the example below.

LINE INTERCEPT: FIELD DATA SHEET

AGENCY/OWNER: Private PROPERTY: Ghost Ranch DATE: 6/29/90

COUNTY: Rio Arriba ACREAGE: 50 OBSERVER: Hanlon

NO. OF LINES: 20 LINE LENGTH: 15 m VEGETATION TYPE: Sagebrush - Grass

Beginning of Cover = B End of Cover = E

Line No.	Sp.	B (dm)	E (dm)	Amount (E-B)	Line No.	Sp.	B (dm)	E (dm)	Amount (E-B)
1	Atca	5	7	2	13	Artr	60	63	3
	Artr	40	46	6		Artr	100	108	8
	Artr	90	93	3		Artr	126	150	24
	Atca	117	120	3	14	Artr	5	9	4
2	Artr	70	75	5	18	Celi	15	17	2
3	Celi	31	33	2					
5	Artr	51	55	4					
	Artr	81	89	8					
	Artr	93	100	7					
6	Artr	40	74	34					
	Celi	85	88	3					
8	Celi	60	61	1					
	Celi	65	66	1					
	Celi	75	76	1					
	Celi	100	101	1					
	Celi	110	112	2					
	Celi	142	147	5					
11	Artr	20	31	11					
	Celi	61	62	1					
	Artr	80	82	2					
	Artr	105	106	1					
	Artr	133	134	1					
12	Op Sp.	70	86	16					
13	Artr	8	13	5					

Figure 5. Sample field data sheet used to illustrate data recording

1. Use the Field Data Sheet to find the amount (dm) of canopy cover recorded for each species on each transect, convert this value to meters (divide by 10), and enter it in the appropriate space on the Line Intercept: Data Analysis form.

2. To find the total amount of canopy cover on a line, add the cover (m) for all species on the line and enter in the last column, "Total Cover (m) per Line."

3. To find the amount of cover provided by each species sampled, add the individual species cover for all lines and enter in the appropriate "Total" block at the bottom of the data analysis form.

4. To find the total amount of cover sampled on the site, add the values in the last column and enter the total at the bottom of the data analysis form.

5. To find the total length of lines sampled at each site, multiply the number of meters per line by the total number of lines sampled.
   Length of lines = Number of meters per line × Number of lines sampled

6. Find the mean percent canopy cover provided by each species, $\bar{x}$ % Cover_{sp}, by substituting the appropriate values in the equation below. Enter each value in the appropriate "% Cover" block at the bottom of the data analysis form.

$$\bar{x} \text{ \% Cover}_{sp} = \frac{\text{Total cover}_{sp}}{\text{Length of lines}} \times 100$$

7. Find the mean percent shrub canopy cover on the site, $\bar{x}$ % Cover_{site}, by substituting in the following equation. Enter this value in the last "% Cover" block at the bottom of the data analysis form.

$$\bar{x} \text{ \% Cover}_{site} = \frac{\text{Total cover}_{site}}{\text{Length of lines}} \times 100$$

Example

In the following example, data have been transferred from the Field Data Sheet (Fig. 5) to the Line Intercept: Data Analysis form (Fig. 6) to illustrate data analysis.

1. The amount of canopy cover provided by each species on Line 1:
   Big sagebrush (*Artemisia tridentata*), 0.9 m
   Four-winged saltbush (*Atriplex canescens*), 0.5 m

2. The total amount of canopy cover on the following lines:
   Line 1 = 1.4 m; Line 5 = 1.9 m; and Line 13 = 4.0 m

3. The amount of canopy cover provided by each species on all lines sampled:
   Big sagebrush, 12.6 m; four-winged saltbush, 0.5 m; winterfat (*Ceratoides linata*), 1.9; and cholla cactus (*Opuntia* sp.), 1.6 m.

4. The total amount of cover on all lines is 16.6 m.

5. Twenty 15-m lines were sampled at this site; therefore, the total length of lines sampled:

   15 meters per line × 20 lines = 300 meters

6. The mean percent canopy cover for big sagebrush, $\bar{x}$ % $Cover_{At}$ on this site is

$$\bar{x}\ \%\ Cover_{At} = \frac{Total\ Cover_{At}}{Length\ of\ lines} \times 100$$

$$= \frac{12.6\ m}{300\ m} \times 100$$

$$= 4.2\%$$

7. The mean percent shrub canopy cover on this site is

$$\bar{x}\ \%\ Cover_{site} = \frac{Total\ cover_{line}}{Length\ of\ lines} \times 100$$

$$= \frac{16.6\ m}{300\ m} \times 100$$

$$= 5.5\%$$

LINE INTERCEPT: DATA ANALYSIS
(Cover in meters)

AGENCY/OWNER: Private PROPERTY: Ghost Ranch OBSERVER: Hanlon DATE: 6-29-90

COUNTY: Rio Arriba ACREAGE: 50 NO. OF LINES: 20 LINE LENGTH: 15 m VEGETATION TYPE: Sagebrush-Grass

Line Number	Amount Cover by Species											Total Cover (m) Per Line
	Artr	Atca	Celi	OpSp								
1	0.9	0.5										1.4
2	0.5											0.5
3			0.2									0.2
5	1.9											1.9
6	3.4		0.3									3.7
8			1.1									1.1
11	1.5		0.1									1.6
12				1.6								1.6
13	4.0											4.0
14	0.4											0.4
18			0.2									0.2
Total (m)	12.6	0.5	1.9	1.6								16.6 m
$\bar{x}$ % Cover	4.2	0.16	0.63	0.53								5.5 %

$$\bar{x}\ \%\ \text{Cover} = \frac{\text{Amount Cover}}{\text{Length of Lines}} \times 100$$

Figure 6. Sample data analysis form used to illustrate transfer of field data and calculations for site data

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APPENDIX A

PROCEDURES FOR DATA COLLECTION

PROCEDURES FOR DATA COLLECTION
(3-Member Field Crew)

1. A stake flag is placed to mark the starting point of the transect. One person holds the end of the tape over the point and records data.

2. A second person takes the tape reel and establishes the transect by walking a compass line to the end of the transect and marking it with a stake flag. The tape is held over this point as in step 1. (The direction traveled to define the transect may be either fixed or random, but lines must not overlap.)

3. The crew members at the transect ends hold the tape tautly with absolutely no sagging, while a third person (observer) reads the amount of shrub canopy that intercepts the tape. The observer calls out the species of shrub, the decimeter on the tape that marks the beginning of cover, and the decimeter that marks the end of cover. Caution: Canopy is not measured if it is encompassed by a larger shrub canopy.

4. The field crew moves to the next sampling station and repeats the above procedure.

PROCEDURES FOR DATA COLLECTION
(2-Member Field Crew)

1. A stake flag is placed to mark the starting point of the transect. One person holds the end of the tape over the point and records data.

2. The second person (observer) paces the length of the transect and marks the end with a stake flag.

3. The observer takes the tape from the first point and walks the transect while reading the amount of shrub canopy over which the tape passes. The observer calls out to the recorder the actual number of decimeters intercepted by the canopy rather than the beginning and ending units. This is convenient because the first unit reading is always 0 dm. Caution: Some canopies encompass so much linear depth that the observer may have difficulty obtaining an accurate reading while also holding the tape.

4. The field crew moves to the next sampling station and repeats the above procedure.

APPENDIX B

LINE INTERCEPT DATA SHEETS

LINE INTERCEPT: FIELD DATA SHEET

AGENCY/OWNER: _____ PROPERTY: _____ DATE: _____

COUNTY: _____ ACREAGE: _____ OBSERVER: _____

NO. OF LINES: ____ LINE LENGTH: ____ VEGETATION TYPE: _____

Beginning of Cover = B End of Cover = E

Line No.	Sp.	B (dm)	E (dm)	Amount (E-B)	Line No.	Sp.	B (dm)	E (dm)	Amount (E-B)

LINE INTERCEPT: DATA ANALYSIS
(Cover in meters)

AGENCY/OWNER: _____ PROPERTY: _____ OBSERVER: _____ DATE: _____

COUNTY: _____ ACREAGE: ____ NO. OF LINES: ____ LINE LENGTH: ____ VEGETATION TYPE: _____

Line Number	Amount Cover by Species											Total Cover (m) Per Line
Total (m)												
$\bar{X}$ % Cover												

$$\bar{x}\ \%\ \text{Cover} = \frac{\text{Amount Cover}}{\text{Length of Lines}} \times 100$$

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1995	Final report

4. TITLE AND SUBTITLE
Line Intercept: Section 6.2.5, U.S. Army Corps of Engineers Wildlife Resources Management Manual

5. FUNDING NUMBERS
EIRP WU 32420

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8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report EL-95-22

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A report on the line intercept vegetative sampling technique is provided as Section 6.2.5 of the U.S. Army Corps of Engineers Wildlife Resources Management Manual. This technique can be used by the Corps District or project biologist to estimate percentage ground cover of shrub communities on project lands. Topics covered include guidelines for technique selection and study design, preparation for sampling, and procedures for data collection, recording, and analysis.

Forest inventory techniques are not generally appropriate for sampling shrub ecotypes, but line intercept can be readily applied in habitat evaluation or range inventory of typical shrublands. Sampling can be conducted by either 2 or 3 field personnel. Cover estimates are made by measuring the lengths of tape line intercepted by shrub canopies and calculating the percent ground cover represented by these lengths.

(Continued)

14. SUBJECT TERMS
See reverse.

15. NUMBER OF PAGES
25

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

13. (Concluded).

Detailed instructions are given for recording and analyzing data; these are accompanied by numerical examples that illustrate each step of recording and data analysis. A reproducible form is also provided for recording and calculating line intercept data.

14. (Concluded).

Cover estimation
Ground cover
Line intercept
Point intercept
Rapid sampling technique
Shrub canopy
Shrub cover
Shrubland inventory
Vegetation sampling